Enthalpy analysis and Heat Exchanger Sizing of an Air-cooled Proton Exchange Membrane Fuel Cell System

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Proton exchange membrane fuel cells (PEMFC's) are becoming increasingly popular for uninterrupted power supply especially in remote areas. In the case of telecom back-up operations, PEMFC systems are often placed in areas of extreme climates, e.g. in Norway or Canada where the temperatures drop below -20 °C in the winter which make liquid-cooled fuel cells impossible. In such cases, air-cooled fuel cell systems are deployed where the air that is fed to the fuel cell serves both as reactant supplier and coolant to remove the waste heat that is generated during fuel cell operation. In some cases the warmer exhaust air is used to pre-heat and also humidify the incoming colder and dryer air stream using an enthalpy wheel.

It is important to thermodynamically understand such a fuel cell system, and in this work the enthalpy streams and the humidity stream are followed throughout the fuel cell system in order to optimize the operating conditions and the performance of such a system. The adjustable parameters include the fan speed that determines the amount of air that is brought into the system, and the size and rotating speed of the rotating enthalpy wheel. In addition, computational fluid dynamics simulations have been carried out to better understand the distribution of the reactant air over the fuel cell stack and the resulting temperature distribution across the stack. These results suggest that the humidifying function of the current enthalpy wheel is negligible and a smaller enthalpy wheel or an ordinary heat exchanger can fulfill the heat recovery demand. Despite the fact that the air enters the stack at a cold temperature, even the forefront of the stack is at a much elevated and desired stack temperature with the help of supplying an acceptable amount of power to an electric stack heater. So a preheating of the air stream by the enthalpy wheel might be unnecessary during steady-state operation.

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